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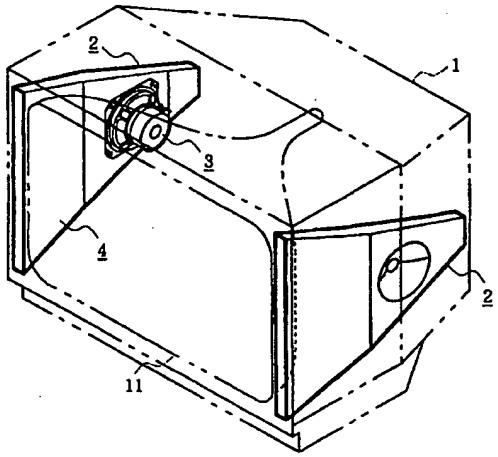
(54) Loudspeaker device and television receiver using the device

(57) A loudspeaker device comprises a loudspeaker 3 and a sound tube 4 having an open end and a closed end opposite thereto and connected to a sound wave radiating portion of the speaker 3 for guiding sound waves radiated from the speaker 3 to the open end of the sound tube 4, the speaker 3 being attached to a side wall of the sound tube 4, the sound tube having a wave guide direction intersecting the direction of radiation of sound waves from the speaker 3, the speaker 3 being attached to the sound tube 4 at a position intermediate between the closed end and the open end. This construction effectively suppresses occurrence of standing waves in the interior of the sound tube 4, realizing satisfactory acoustic characteristics over a wide range of low to high frequencies.

FIG. 1



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Description

FIELD OF THE INVENTION

The present invention relates to loudspeaker devices comprising a loudspeaker and a sound tube connected thereto, and to television receivers having such devices.

BACKGROUND OF THE INVENTION

With reference to FIG. 22, television receivers comprise a cathode-ray tube 11 accommodated in a cabinet 1, and a pair of opposite loudspeakers 12 arranged in dead spaces inside the cabinet 1 around the cathode-ray tube 11. The sound waves emitted by each speaker 12 are guided to the front side of the cabinet 1 by a sound tube 13 connected to the speaker 12.

With increases in the size of television receivers in recent years, speakers 12 of increased diameter are also in use. When such speakers 12 of large diameter are to be arranged at opposite sides of the cathode-ray tube 11 as in FIG. 22, the speakers 12 can not be entirely accommodated in the above-mentioned dead spaces inside the cabinet 1, and there arises a need, for example, to bulge the side walls of the cabinet 1. This gives rise to the problem of increasing the lateral width of the cabinet 1.

Accordingly, it appears useful to connect a sound tube 14 to each speaker 12 directed laterally as slightly inclined with respect to the front side of the cabinet 1 as shown in FIG. 23.

The large speaker 12 can then be disposed in the dead space inside the cabinet 1 in a compact arrangement.

However, the speaker device shown in FIG. 23 has the problem of impaired acoustic characteristics especially at medium frequencies since the sound waves radiated by the speaker 12 are deflected at a large angle close to 90 degrees and then guided into the sound tube 14.

With either of the speaker devices shown in FIGS. 22 and 23, the sound waves radiated from the speaker 12 and guided into the sound tube 13 or 14 are thereafter forwardly released from the open end of the sound tube. At this time, some of the sound waves are reflected owing to a marked change in the acoustic impedance at the tube open end and return toward the speaker 12 to produce standing waves.

For example, in the case where 3/4 of the wavelength of the standing wave is equal to the length of the sound tube (three-quarter wavelength standing wave), resonance occurs, and a marked peak appears in the sound pressure-frequency characteristics at around 700 Hz to 1 kHz to result in impaired acoustic characteristics especially at medium frequencies.

To eliminate the disturbance of sound pressure-frequency characteristics due to standing waves, a speaker device is proposed wherein a sound tube is internally provided with a sound absorbing material surrounding the sound wave radiating portion of a speaker and adapted to absorb standing waves (Unexamined Japanese Patent Publication HEI 5-168082). However, this device is unable to effectively absorb standing waves since the sound waves traveling toward the front face of the speaker upon reflection fail to impinge on the absorbing material.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a loudspeaker device wherein the wave guide direction of a sound tube is inclined with respect to the direction of radiation of sound waves from a speaker and which is adapted to effectively absorb standing waves so as to realize satisfactory acoustic characteristics over a wide range of low to high frequencies.

The present invention provides a loudspeaker device which comprises a loudspeaker 3 and a sound tube 4 having an open end and a closed end opposite thereto and connected to a sound wave radiating portion of the speaker.

The speaker 3 is attached to a side wall of the sound tube 4, and the sound tube 4 has a wave guide direction intersecting the direction of radiation of sound waves from the speaker 3. The speaker 3 is attached to the sound tube 4 at a position intermediate between the closed end and the open end.

The standing wave occurring in the interior of the sound tube 4 has a node at the closed end of the sound tube 4 and an antinode at the open end thereof, and one or a plurality of antinodes occur also between the closed end and the open end to effect resonance. Accordingly, with the conventional device wherein the speaker is attached to the closed end portion of the sound tube, the position of attachment is opposed to the position of the node of the standing wave, permitting the speaker drive force to efficiently contribute to the occurrence of standing waves, hence occurrence of great standing waves.

With the speaker device of the present invention, on the other hand, the speaker 3 is attached to the sound tube 4 at an intermediate portion between the closed end and the open end, and the position of attachment is opposed to the position of one antinode of the standing wave. This reduces the speaker drive efficiency as to standing waves, consequently suppressing standing waves and improving the acoustic characteristics especially at medium frequencies.

More specifically, the speaker 3 is attached to the sound tube 4 at a position spaced apart from the closed end toward the open end by a distance corresponding to about 1/3 of the entire length of the sound tube 4. The position of antinode of the standing wave is, for example, spaced apart from the closed end toward the open end by a distance corresponding to about 1/3 of the entire length of the sound tube 4. In the specific arrangement wherein the speaker 3 is attached at this

position, the position of attachment of the speaker 3 is opposed to the position of antinode of a three-quarter wavelength standing wave, whereby the resonance of the three-quater wavelength standing wave is effectively inhibited.

In a specific arrangement, the sound tube 4 is packed with a sound absorbing material 5 in an interior portion thereof closer to the closed end than the position of attachment of the speaker 3. With this specific arrangement, all the reflected waves returning from the open end of the sound tube 4 are absorbed by the sound absorbing material 5 upon impinging thereon.

Further stated specifically, the wave guide channel of the sound tube 4 is approximately constant or increases in cross sectional area from the position of attachment of the speaker 3 toward the open end. The wave guide channel of the sound tube 4 further decreases in cross sectional area from the position of attachment of the speaker 3 toward the closed end. In this specific construction, the cross sectional size of the sound tube open end where reflected waves occur differs from that of the sound tube closed end to be eventually reached by the reflected waves, so that this asymmetry attenuates the reflected waves at the closed end.

The sound tube 4 is provided on an inside wall thereof with a frustoconical protuberance 6 bulging toward the speaker 3 and opposed to the sound wave radiating portion thereof. Whereas the recessed shape of the speaker diaphragm produces a marked change in the cross sectional area of the wave guide channel at the outlet of the speaker 3, the change is offset by the protuberance 6 of the above specific construction. This diminishes the variation of the acoustic impedance at the connection between the speaker 3 and the sound tube 4.

In another specific arrangement, the sound tube 4 is internally provided with a reflector 7 at a specified position closer to the closed end than the position of attachment of the speaker 3 for partly blocking the wave guide channel at the specified position. This specific arrangement is effective for affording improved acoustic characteristics at high frequencies, realizing well-balanced acoustic characteristics at medium to high frequencies.

Furthermore, terminals 32, 32 for passing current through the speaker 3 are supported on a frame 30 at a position away from the center of the speaker 3 toward the open end of the sound tube 4, and litz wires 33, 33 extend from the respective terminals 32, 32 toward a diaphragm 31. In this specific arrangement, the imbalance of the sound pressure resistance relative to the diaphragm 31 of the speaker 3, i.e., the imbalance of the sound pressure resistance that is greater at the closed end side than at the open end side, is offset by an increase in the equivalent mass due to the weight of the litz wires 33 extending from the terminals 32 to the diaphragm 31 and lead wires, and the weight of solder for fixing the litz wires 33 to the lead wires. Consequently, the diaphragm 31 vibrates only unidimensionally along the direction of radiation of sound waves, whereby a distortion-free high sound quality is available.

The invention provides a television receiver having housed in a cabinet 1 a cathode-ray tube 11 and a pair of loudspeaker devices 2, 2 arranged at opposite sides of the cathode-ray tube 11, each of the speaker devices 2 comprising a loudspeaker 3 disposed in an inner portion of the cabinet 1 and directed laterally, and a sound tube 4 connected to a sound wave radiating portion of the speaker 3 and extending from a closed end in an inward portion of the cabinet 1 to an open end at the front side of the cabinet 1. The speaker 3 is attached to a side wall of the sound tube 4, and the sound tube 4 has a wave guide direction intersecting the direction of radiation of sound waves from the speaker 3. The speaker 3 is attached to the sound tube 4 at a position intermediate between the closed end and the open end.

The televation receiver embodying the present invention has inside the cabinet 1 the pair of speaker devices 2, 2 arranged at opposite sides of the cathode-ray tube 11, with the speakers 3 arranged as directed laterally in the inner portion of the cabinet 1 remote from its front side, so that the speakers 3, even if having an increased diameter, can be compactly arranged utilizing dead spaces without necessitating a cabinet 1 of larger lateral width. Further because the speaker 3 of each speaker device 2 is attached to the sound tube 4 at a position intermediate between the closed end and the open end, standing waves are inhibited effectively.

The inclination of the wave guide direction of the sound tube with respect to the direction of radiation of sound waves from the speaker gives rise to the problem that peak dips occur as centered around medium frequencies, whereas such dips are effectively suppressed in the case of the speaker device of the invention and the television receiver incorporating the device, whereby satisfactory acoustic characteristics are available over a wide range of low to high frequencies.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary perspective view showing a television receiver according to the invention;

FIG. 2 is a perspective view of a speaker device embodying the invention;

FIG. 3 is a sectional view of the speaker device;

FIG. 4 is an exploded perspective view of the speaker device;

FIG. 5 is an exploded perspective view of a speaker device including reflectors;

FIG. 6 is a fragmentary perspective view of the speaker device;

FIG. 7 is a fragmentary perspective view of a speaker device with terminals provided at an altered position;

FIG. 8 is a sectional view of the speaker device;

FIG. 9 is a perspective view of an experimental speaker device;

FIG. 10 is a sectional view of the speaker device;

FIG. 11 is a diagram showing different resonance modes;

FIG. 12 is a graph showing sound pressure-frequency characteristics available when the closed end of a sound tube is driven;

FIG. 13 is a diagram showing two experimental speaker devices which are different in the position of attachment of the speaker;

FIG. 14 is a graph showing the sound pressure-frequency characteristics of one of the speaker devices wherein the speaker is installed at a distance of 1/2 from the closed end;

FIG. 15 is a graph showing the sound pressure-frequency characteristics of the other device wherein the speaker is installed at a distance of 1/3 from the closed end;

FIG. 16 is a diagram showing an experimental speaker device packed with a sound absorbing material;

FIG. 17 is a graph showing the sound pressure-frequency characteristics of the speaker device;

FIG. 18 is a diagram showing an experimental speaker device having a protuberance as opposed to its speaker;

FIG. 19 is a graph showing the sound pressure-frequency characteristics of the speaker device;

FIG. 20 is a diagram showing an experimental speaker device having reflectors;

FIG. 21 is a graph showing the sound pressure-frequency characteristics of the speaker device;

FIG. 22 is a plan view showing speaker devices as arranged in a conventional television receiver; and

FIG. 23 is a plan view showing another conventional example.

DETAILED DESCRIPTION OF EMBODIMENTS

Several embodiments of the invention will be desribed below in detail with reference to the drawings.

FIG. 1 shows a television receiver embodying the invention and incorporating loudspeaker devices 2 of the invention therein. The speaker devices 2, 2 in an opposed pair are arranged on opposite sides of a cathode-ray tube 11 in the interior of a cabinet 1.

Each speaker device 2 comprises a loudspeaker 3 disposed as directed laterally in an inner portion of the cabinet 1 remote from its front side utilizing a dead space inside the cabinet 1, and a sound tube 4 having a closed end in an inward portion of the cabinet 1 and an open end facing the front side of the cabinet 1. The front side of the speaker 3 is attached to a side wall of the sound tube 4. The speaker 3 is a common cone dynamic speaker as seen in FIG. 2 and has a diaphragm 31 in the form of a cone of paper and supported by a damper on a frame 30. The diaphragm 31 is driven by passing current through the speaker via a pair of terminals 32,32.

With reference to FIG. 3, the speaker 3 is attached to the sound tube 4 at a position spaced apart from the closed end toward the open end by a distance corresponding to 1/3 of the entire length of the sound tube 4. The sound tube 4 comprises the combination of a first panel 41 and a second panel 42, so that the two panels 41, 42 define a forward wave guide channel 43 extending from the position of the speaker 3 toward the open end, and a rearward wave guide channel 44 extending from the position of the speaker 3 toward the closed end.

As shown in FIG. 4, the width of the forward wave guide channel 43 of the sound tube 4 increases toward the open end according to a predetermined function, and at the same time, the thickness thereof decreases toward the open end in reciprocal relation to the function, with the result that the channel 43 remains constant in cross sectional area from the position of attachment of the speaker 3 to the open end. Consequently, the open end of the sound tube 4 has a vertically elongated slender rectangular opening at the front side of the cabinet 1. This minimizes the increase of the lateral width of the cabinet 1.

In contrast, the rearward wave guide channel 44 of the sound tube 4 gradually decreases in cross sectional area toward the closed end. The rear portion of the channel 44 is packed with a sound absorbing material 5.

A circular aperture 45 for admitting sound waves from the speaker 3 into the sound tube 4 therethrough is formed in the first panel 41 at the position where the speaker 3 is attached to the tube 4. The second panel 42 has a frustoconical protuberance 6 in conformity with the shape of the speaker diaphragm 31, opposed to the circular aperture 45 of the first panel 41 and bulging toward the speaker 3.

FIGS. 5 and 6 show a loudspeaker device which has a pair of reflectors 7, 7 spaced apart from each other and arranged at the inlet of the rearward wave guide channel 44 of the sound tube 4. The channel 44 is similarly packed with a sound absorbing material 5 to the rear of these reflectors 7, 7.

FIGS. 7 and 8 show a loudspeaker device wherein the terminals 32, 32 of the speaker 3 are supported on the frame 30 at a position away from the center of the speaker 3 toward the open end of the sound tube 4. Litz wires 33, 33 extend from the respective terminals 32, 32 toward the diaphragm 31.

Experimental speaker devices of the type shown in FIGS. 9 and 10 were prepared to substantiate the advantages of the speaker devices described above by experiments. FIGS. 11 to 21 show the results of the experiments.

As shown in FIGS. 9 and 10, the experimental speaker device had an experimental sound tube 8 with a constant cross sectional area over the entire length of its wave guide channel and a speaker 3 attached to a side wall of the tube 8, and was basically the same as the speaker device of the invention in construction. A microphone 9 was installed as opposed to the open end

of the sound tube 8 to determine the sound pressure-frequency characteristics.

The experimental sound tube 8 was 350 mm in overall length and had a rectangular cross section measuring 105 mm x 50 mm. The microphone 9 was spaced apart from the open end of the sound tube 8 by 10 mm.

FIG. 11 shows standing waves occurring in a sound tube of constant cross sectional area.

Assuming that the length of the sound tube is L, the frequency F at which a standing wave occurs is expressed by Equation 1 given below. Equation 1

$$F = (c/4L) \times (2n + 1)$$

where c is the sound velocity, and n is an integer (0, 1, 2, ...).

Suppose L = 0.35 m, and c = 340 m/s. The frequencies F1, F2 and F3 at which a quarter-wavelength standing wave, three-quarter wavelength standing wave and five-quarter wavelength standing wave occur respectively are as follows.

F1 = 243 Hz
F2 = 729 Hz
F3 = 1214 Hz

In the case where the closed end of the sound tube is driven by a speaker with the frequency characteristics indicated in a broken line in FIG. 12, the frequency characteristics of sound waves released from the sound tube involve repeated marked peak dips at medium to high frequencies as indicated in a solid line, hence disturbed characteristics. Incidentally, the solid-line frequency characteristics were calculated by computer simulation.

On the other hand, the frequency characteristics shown in FIGS. 15 and 14 were obtained from the results of experiments conducted for an A-type device wherein the speaker was installed at a position 1/3 of the entire length of the sound tube away from the closed end and for a B-type device wherein the speaker was positioned 1/2 of the tube length away from the closed end, as shown in FIG. 13 respectively.

More specifically, with the B type wherein the speaker is in the position of 1/2 and which is represented by a solid line in FIG. 14, the characteristics curve slightly levels off in a frequency band (around 1 kHz) unlike the case wherein the closed end is driven (broken line), but shows a great dip around 300 Hz and indicates a reduction of sound pressure around 1500 Hz.

On the other hand, with the A type wherein the speaker is in the position of 1/3 and which is represented by a solid line in FIG. 15, peak dips are fully suppressed at medium to high frequencies with disappearance of the dip around 300 Hz, and sufficiently high sound pressure levels are available at 1000 Hz to 1800 Hz, hence satisfactory sound pressure-frequency characteristics.

This advantage results from the fact that the position of 1/3 corresponds to an antinode of the three-quarter wavelength standing wave (occurring at a frequency of 729 Hz in this experiment). It is thought that driving the position of the antinode reduces the drive efficiency as to the occurrence of standing waves to inhibit standing waves.

The experimental result of FIG. 15 also reveals that the peak at medium frequencies of around 729 Hz remarkably diminishes, substantiating the advantage of the speaker device of the invention.

FIG. 16 shows a D-type experimental speaker device wherein the sound tube is packed with a sound absorbing material in the rear portion thereof. FIG. 17 shows the frequency characteristics of the device determined.

As represented by a solid line in FIG. 17, peak dips are effectively suppressed at medium to high frequencies. This appears attributable to the fact that the sound waves returning upon reflection at the open end of the sound tube impinge on and are absorbed by the sound absorbing material without leaking, whereby the resonance of standing waves is inhibited.

FIG. 18 shows an E-type speaker device wherein the sound tube has a protuberance conforming to the shape of the diaphragm and opposed to the speaker. FIG. 19 shows the frequency characteristics of the device determined.

As represented by a solid line in FIG. 19, the device exhibits higher sound pressures than the D-type speaker device (broken line) over the range of 800 Hz to 2500 Hz. This is thought attributable to the following reason. At the location where the sound waves radiated from the speaker diaphragm of the D-type device are led into the sound tube, the wave guide channel has an abruptly enlarged portion defined by the recessed diaphragm, whereas with the E-type device, the cross sectional area of the wave guide channel at the speaker outlet is made to vary uniformly by the provision of the protuberance, thereby permitting the sound tube to have a cross sectional area free of abrupt changes and ensuring a uniform variation of acoustic impedance when the sound waves radiated from the speaker pass through the sound tube.

FIG. 20 shows an F-type speaker device which has a pair of reflectors on the front side of a sound absorbing material in the interior of the sound tube. FIG. 21 shows the frequency characteristics of the device determined.

As represented by a solid line in FIG. 21, the dip in the range of 6000 Hz to 7000 Hz is made lesser than in the case of the E-type device (broken line). This reveals that the sound pressure is adjustable in the range of high frequencies by the provision of the reflectors

According to the invention, the speaker 3 is attached to the sound tube 4 at an intermediate portion thereof, preferably at a position spaced apart from the

closed end by a distance corresponding to about 1/5 to about 3/5, more preferably 1/3, of the entire length of the tube 4, whereby peak dips occurring in the sound pressure-frequency characteristics of the speaker device can be effectively diminished as described above. Further when the sound tube is packed with the sound absorbing material 5, formed with the protuberance 6 and provided with the reflector 7, improved frequency characteristics are made available over the range of medium to high frequencies.

Furthermore, the provision of the terminals 32, 32 of the speaker 3 as shifted from the closed end side of the sound tube 4 to the open end side thereof obviates the imbalance of the resistance to be loaded when the diaphragm 31 vibrates, affording a distortion-free high sound quality.

Since the forward wave guide channel 43 of the sound tube 4 is given a constant cross sectional area as the tube extends forward, the tube is constant in acoustic impedance from the position of attachment of the speaker 3 to the open end and unlikely to permit occurrence of reflected waves at an intermediate portion of the forward wave guide channel 43 and to function as a so-called Helmholtz resonator.

With the television receiver embodying the invention, a pair of opposite speaker devices 2, 2 can be compactly arranged inside the cabinet 1 effectively utilizing dead spaces created at opposite sides of the cathode-ray tube 11. Speakers 3 of increased diameter are therefore readily usable.

The embodiments described above are intended to illustrate the present invention and should not be construed as limiting the invention set forth in the appended claims or reducing the scope thereof. Furthermore, the devices of the invention are not limited to the embodiments in construction but can of course be modified variously without departing from the spirit of invention as set forth in the claims.

For example, the forward wave guide channel 43 of the sound tube 4 is designed to have a constant cross sectional area toward the open end according to the embodiments, whereas the forward wave guide channel 43 can be enlarged toward the open end to obtain a horn effect.

While the device of the invention has the basic feature that the speaker 3 is attached to an intermediate portion of the sound tube 4, the device is also packed with the sound absorbing material 5, formed with the protuberance 6 and provided with the reflectors 7 and with the speaker terminals 32, 32 in an altered position as additional features. However, all of these additional means need not be provided, but one or some of these means as optionally selected can be added to the device.

Claims

1. A loudspeaker device comprising a loudspeaker (3) and a sound tube (4) having an open end and a closed end opposite thereto and connected to a sound wave radiating portion of the speaker (3) for guiding sound waves radiated from the speaker (3) to the open end of the sound tube (4), the speaker (3) being attached to a side wall of the sound tube (4), the sound tube (4) having a wave guide direction intersecting the direction of radiation of sound waves from the speaker (3), the speaker (3) being attached to the sound tube (4) at a position intermediate between the closed end and the open end.

2. A loudspeaker device as defined in claim 1 wherein a wave guide channel of the sound tube (4) extends from the closed end to the open end and has a rearward wave guide channel portion extending to the closed end and positioned at the closed end side of a central wave guide channel portion opposed to the sound wave radiating portion of the speaker (3).

3. A loudspeaker device as defined in claim 1 wherein the speaker (3) is attached in corresponding relation with the position of an antinode of a standing wave occurring in the interior of the sound tube (4).

4. A loudspeaker device as defined in claim 3 wherein the speaker (3) is attached to the sound tube (4) at a position spaced apart from the closed end toward the open end by a distance corresponding to about 1/5 to about 3/5 of the entire length of the sound tube (4).

5. A loudspeaker device as defined in claim 4 wherein the speaker (3) is attached to the sound tube (4) at a position spaced apart from the closed end toward the open end by a distance corresponding to about 1/3 of the entire length of the sound tube (4).

6. A loudspeaker device as defined in claim 1 wherein the sound tube (4) is packed with a sound absorbing material (5) in an interior portion thereof closer to the closed end than the position of attachment of the speaker (3).

7. A loudspeaker device as defined in claim 1 wherein the sound tube (4) has a wave guide channel approximately constant or increasing in cross sectional area from the position of attachment of the speaker (3) toward the open end.

8. A loudspeaker device as defined in claim 1 wherein the sound tube (4) has a wave guide channel decreasing in cross sectional area from the position of attachment of the speaker (3) toward the closed end.

9. A loudspeaker device as defined in claim 1 wherein the sound tube (4) is provided on an inside wall thereof with a frustoconical protuberance (6) bulg-

ing toward the speaker (3) and opposed to the sound wave radiating portion thereof.

10. A loudspeaker device as defined in claim 1 wherein the sound tube (4) is internally provided with a reflector (7) at a specified position closer to the closed end than the position of attachment of the speaker (3) for partly blocking a wave guide channel at the specified position.

11. A television receiver having housed in a cabinet (1) a cathode-ray tube (11) and a pair of loudspeaker devices (2), (2) arranged at opposite sides of the cathode-ray tube (11), each of the speaker devices (2) comprising a loudspeaker (3) disposed in an inner portion of the cabinet (1) and directed laterally, and a sound tube (4) connected to a sound wave radiating portion of the speaker (3) and extending from a closed end in an inward portion of the cabinet (1) to an open end at the front side of the cabinet (1), the speaker (3) being attached to a side wall of the sound tube (4), the sound tube (4) having a wave guide direction intersecting the direction of radiation of sound waves from the speaker (3), the speaker (3) being attached to the sound tube (4) at a position intermediate between the closed end and the open end.

FIG. 1

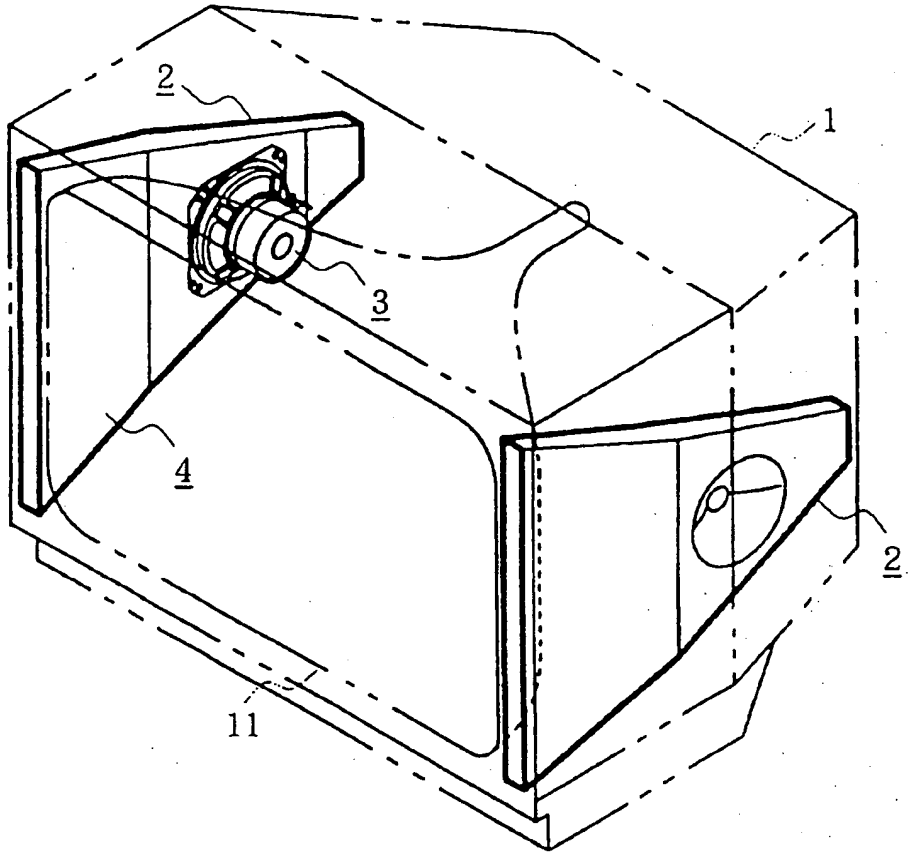


FIG. 2

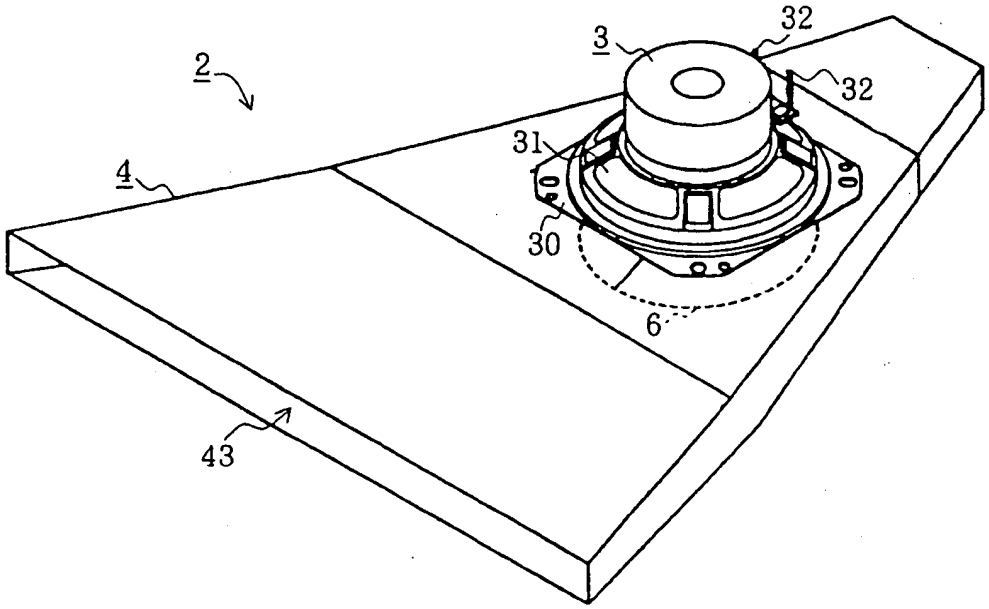


FIG. 3

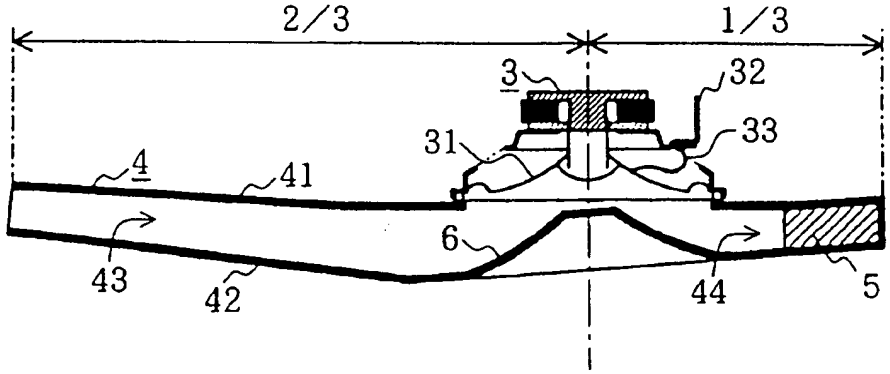


FIG. 4

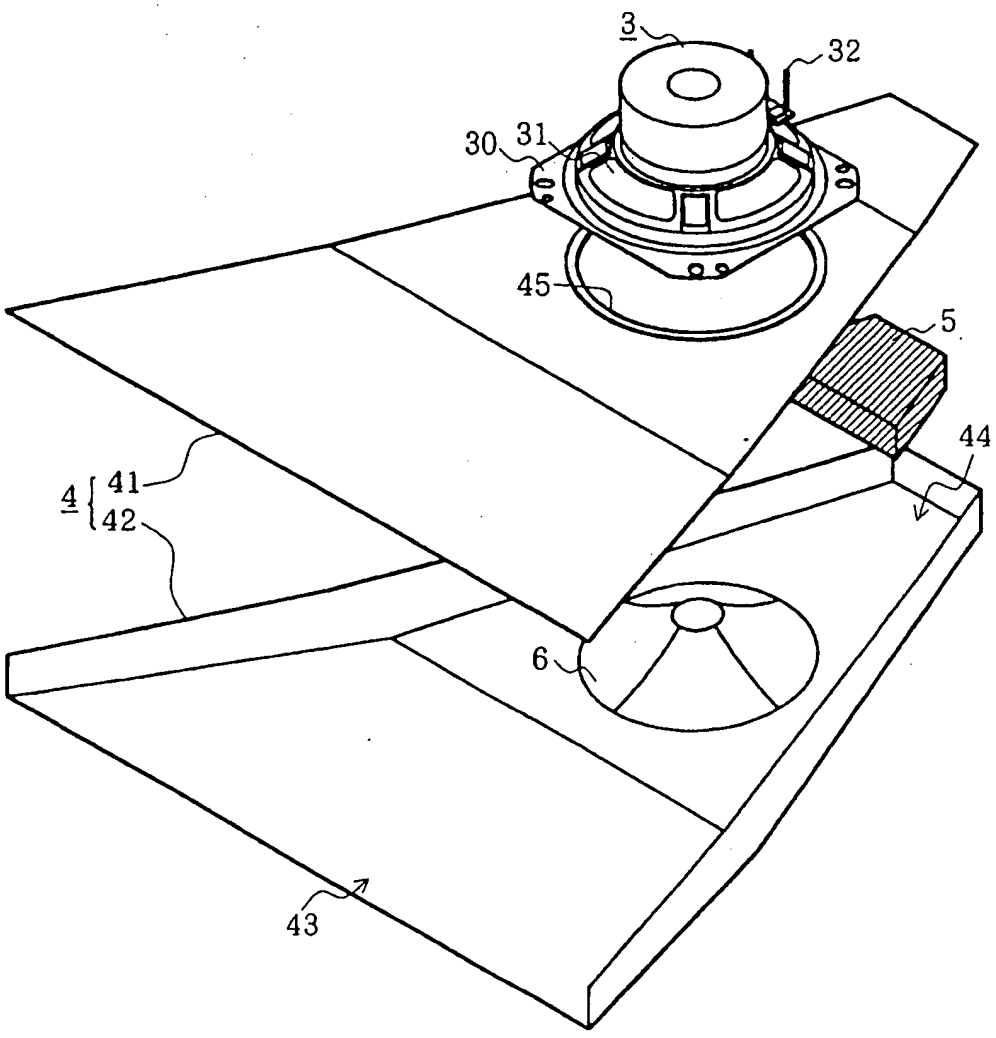


FIG. 5

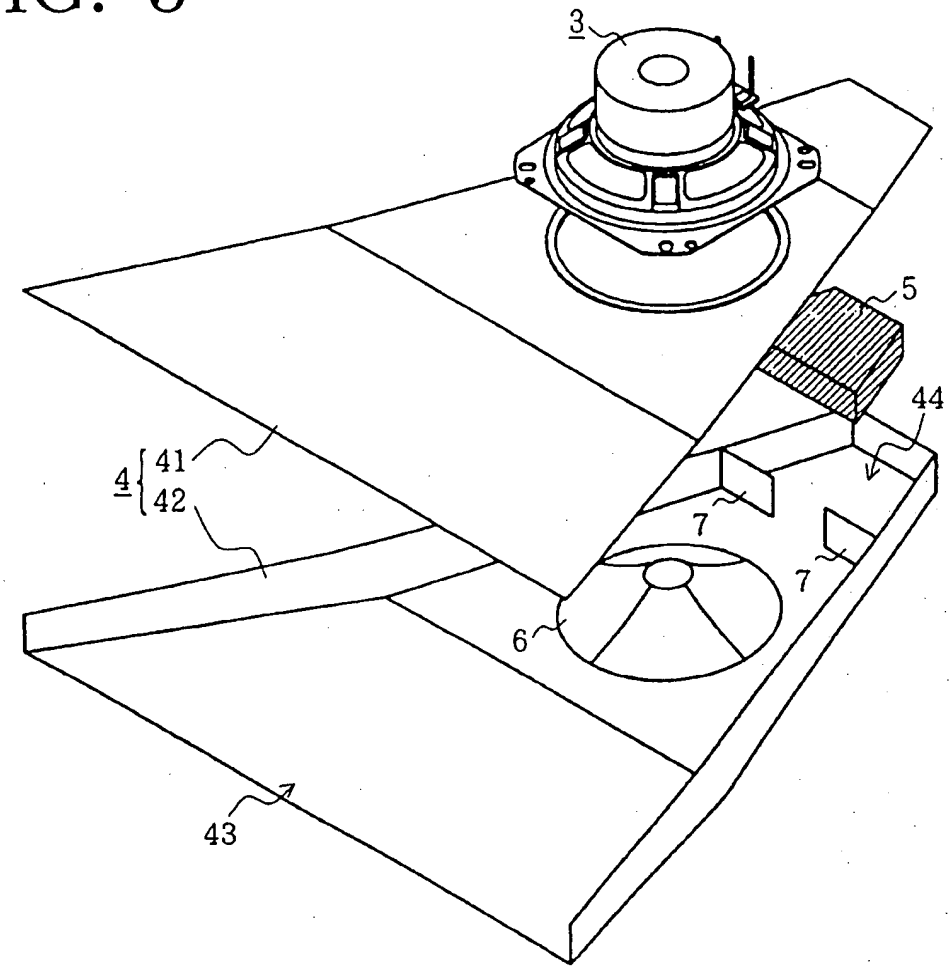


FIG. 6

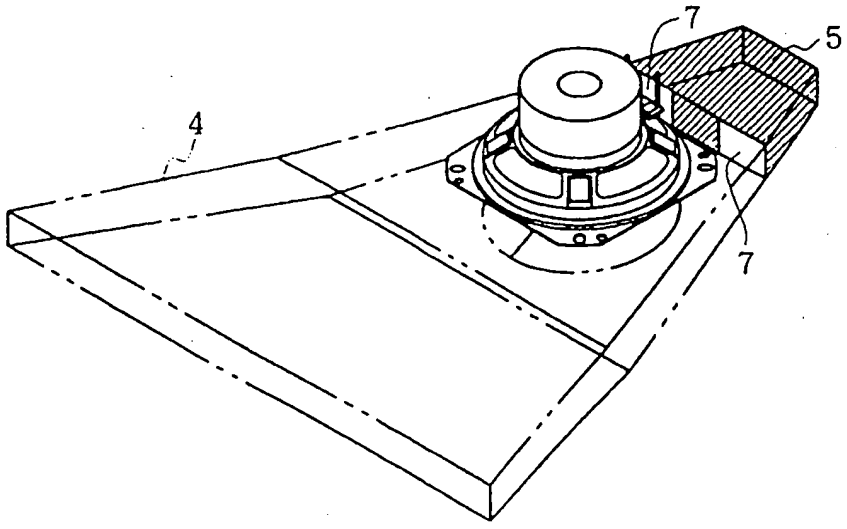


FIG. 7

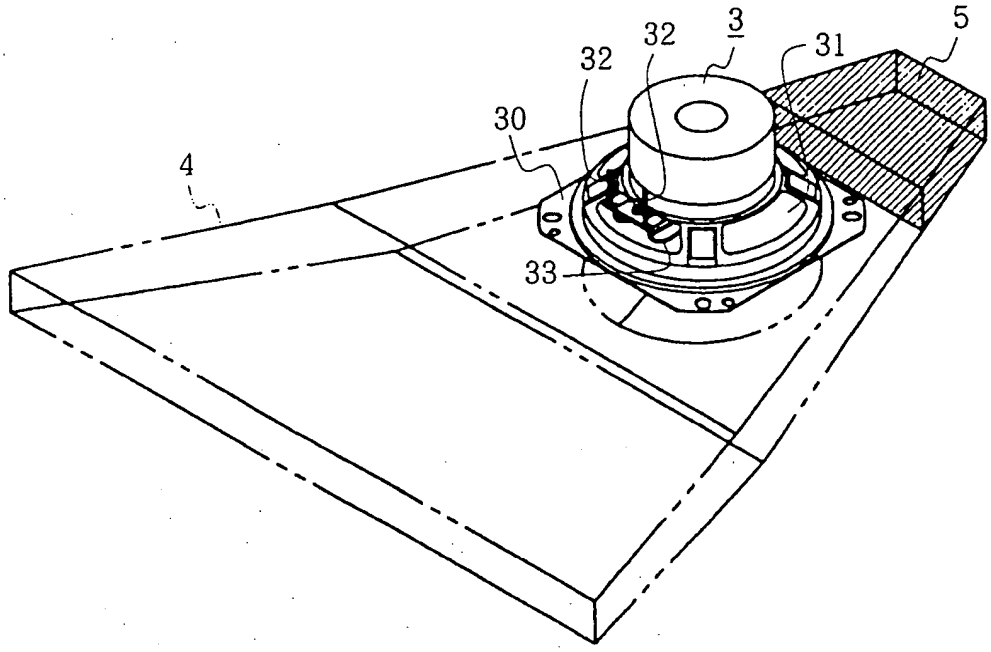


FIG. 8

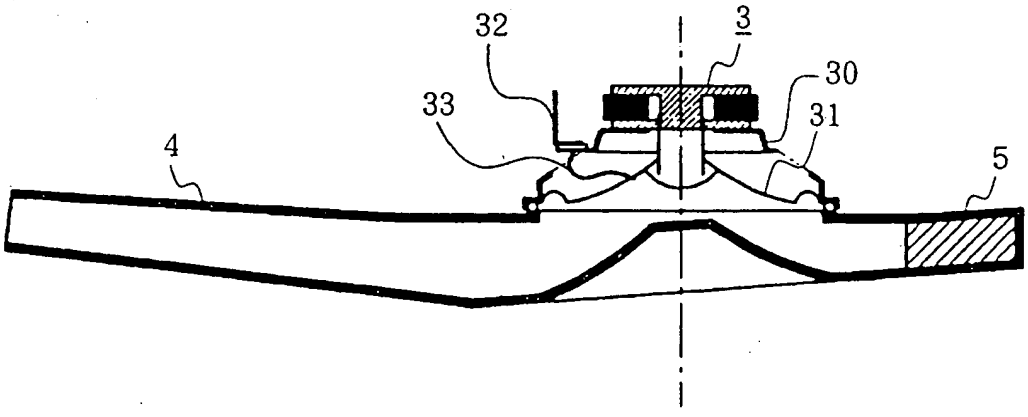
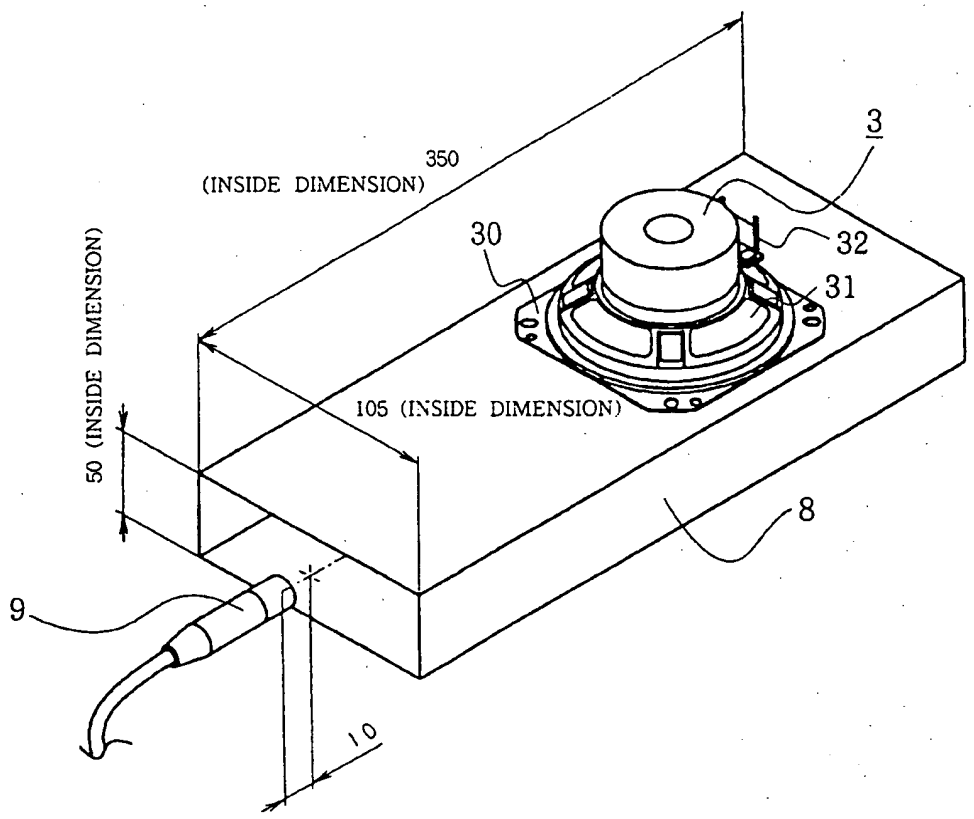


FIG. 9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(INSIDE DIMENSION)
3
30
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31
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105 (INSIDE DIMENSION)
8
9
10

FIG. 10

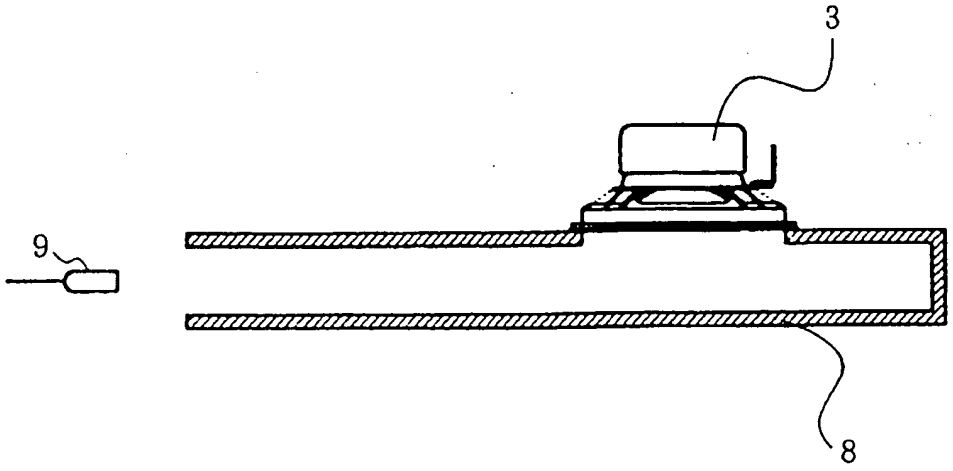

3
9
8

FIG. 11

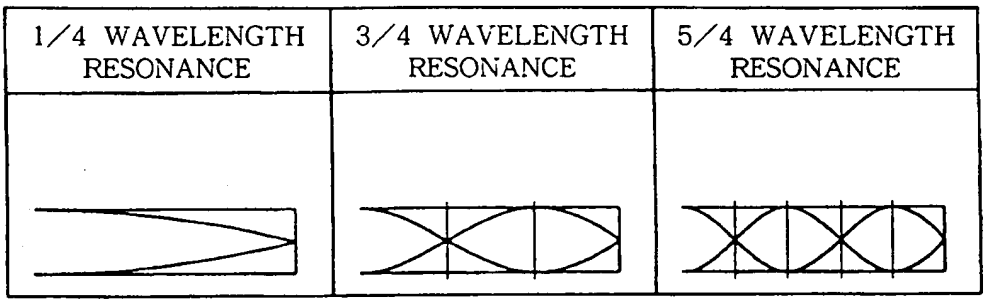

1/4 WAVELENGTH RESONANCE
3/4 WAVELENGTH RESONANCE
5/4 WAVELENGTH RESONANCE

FIG. 12

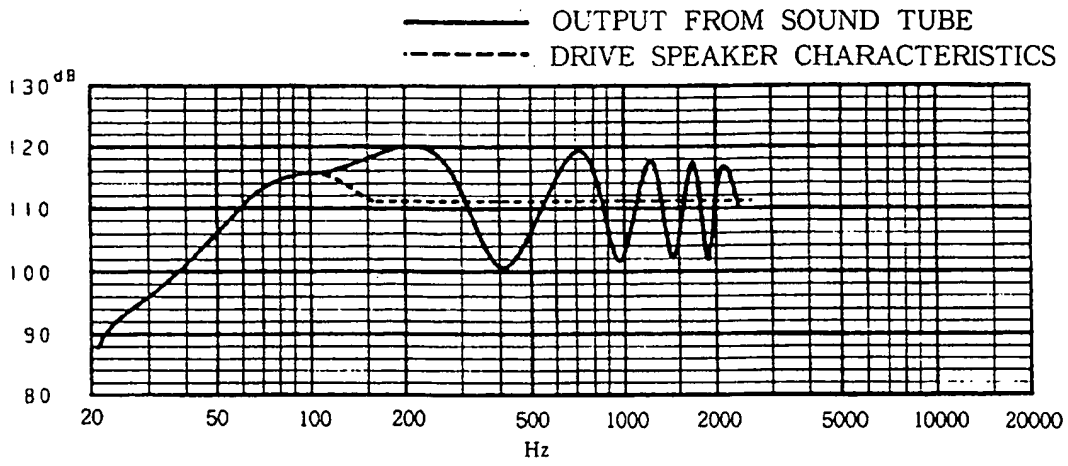

OUTPUT FROM SOUND TUBE
DRIVE SPEAKER CHARACTERISTICS
130 dB
120
110
100
90
80
20
50
100
200
500
1000
2000
5000
10000
20000
Hz

FIG. 13

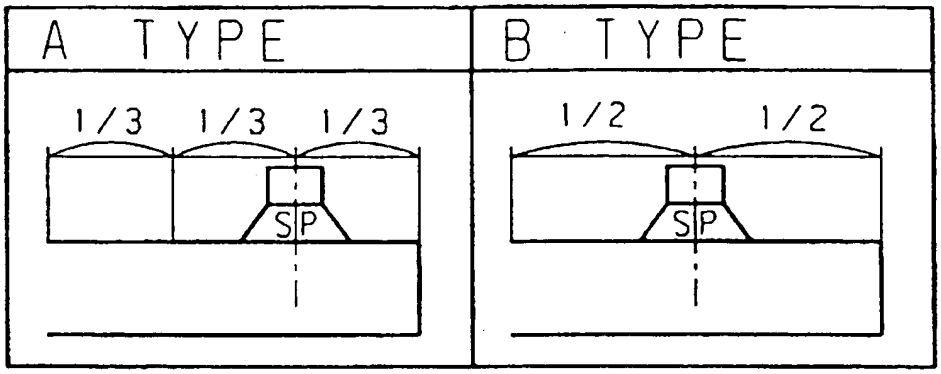


FIG. 14

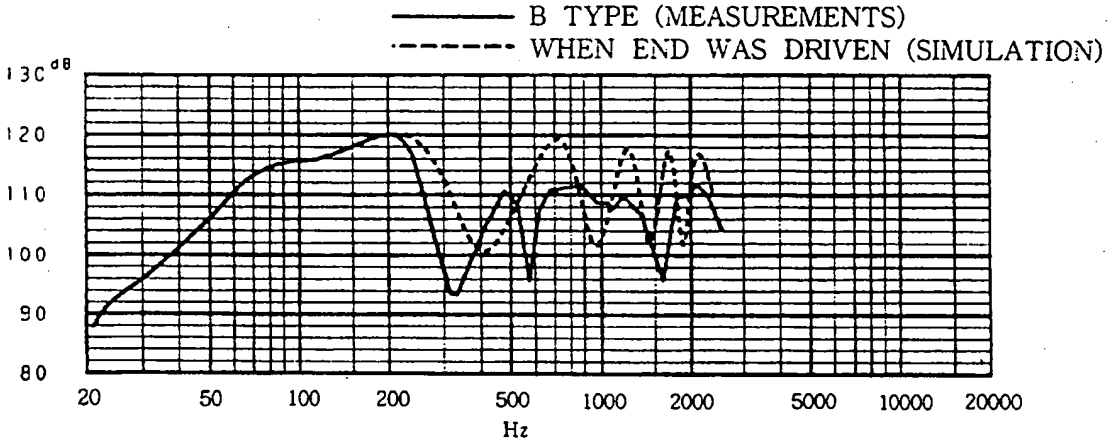


FIG. 15

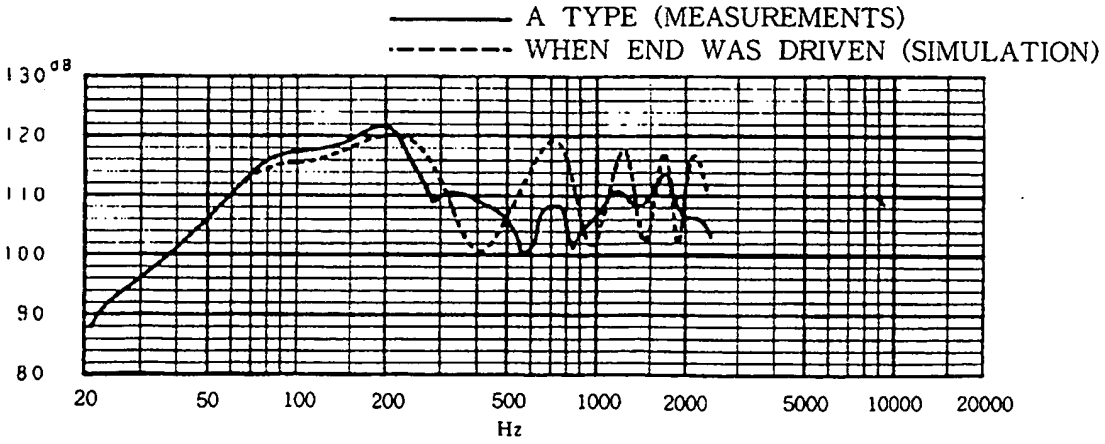


FIG. 16

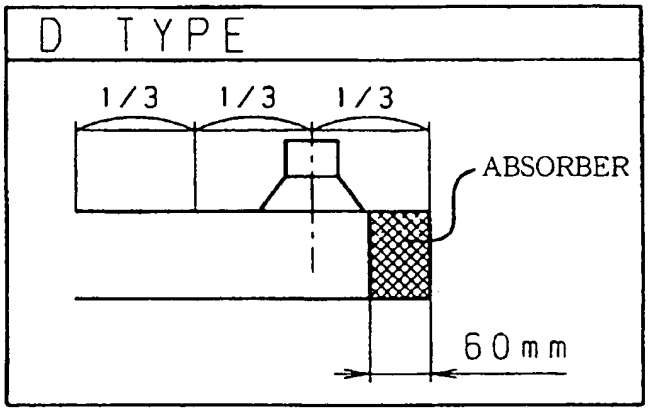

D TYPE
1/3
1/3
1/3
ABSORBER
60mm

FIG. 17

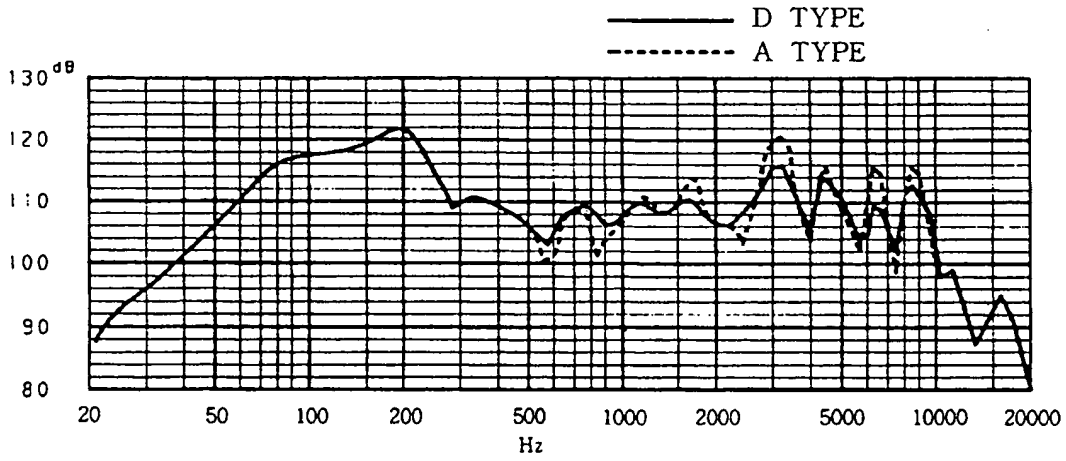

D TYPE
A TYPE
130dB
120
110
100
90
80
20
50
100
200
500
1000
2000
5000
10000
20000
Hz

FIG. 18

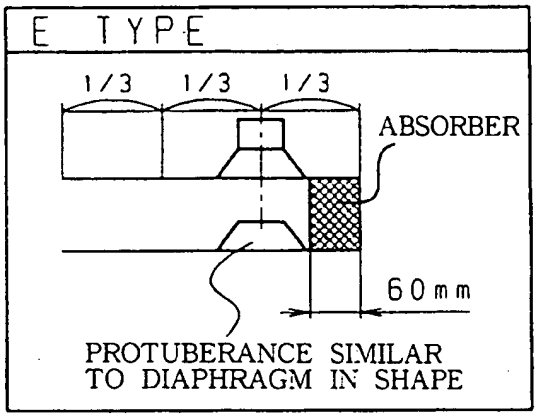

E TYPE
1/3
1/3
1/3
ABSORBER
60mm
PROTUBERANCE SIMILAR
TO DIAPHRAGM IN SHAPE

FIG. 19

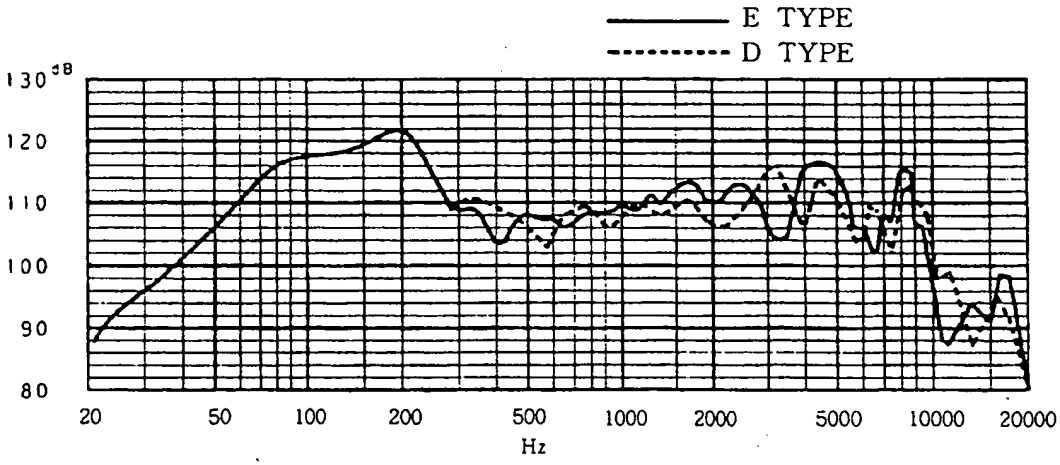

E TYPE
D TYPE
dB
130
120
110
100
90
80
20
50
100
200
500
1000
2000
5000
10000
20000
Hz

FIG. 20

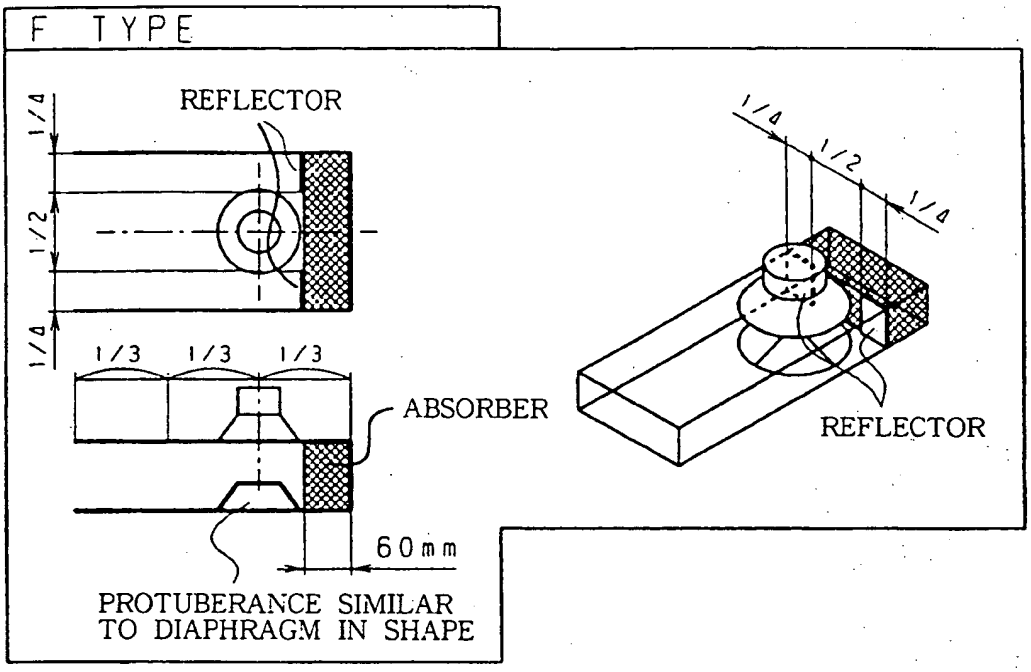

F TYPE
REFLECTOR
1/4
1/2
1/4
1/3
1/3
1/3
ABSORBER
60mm
PROTUBERANCE SIMILAR
TO DIAPHRAGM IN SHAPE
1/4
1/2
1/4
REFLECTOR

FIG. 21

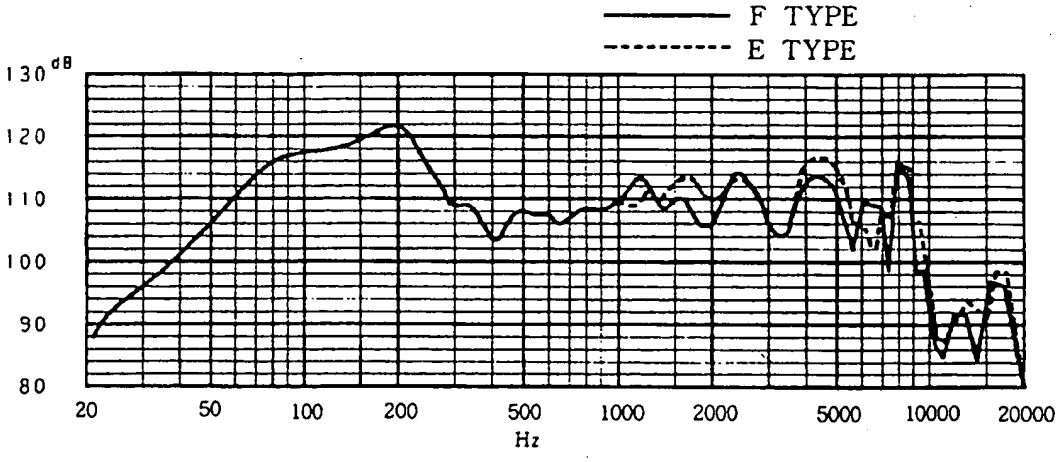

F TYPE
E TYPE
130 dB
120
110
100
90
80
20
50
100
200
500
1000
2000
5000
10000
20000
Hz

FIG. 22

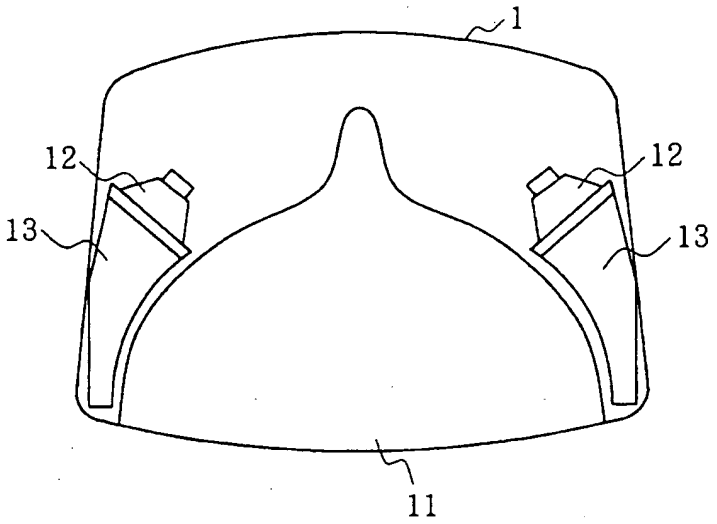
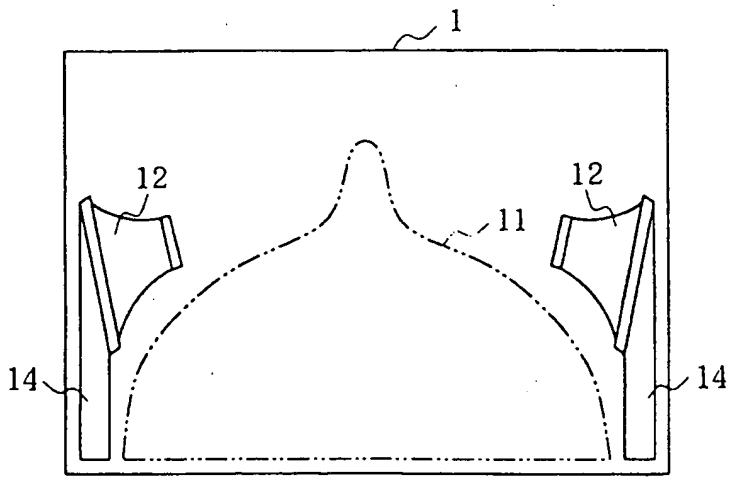


FIG. 23



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 10 8264

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	EP-A-0 451 885 (PHILIPS NV) * column 3, line 57 - column 4, line 57; figures 2,3 *	1,2,7,9 11	H04R5/02 H04R1/34 H04R1/28 H04N5/64
Y A	EP-A-0 451 991 (MATSUSHITA ELECTRIC IND CO LTD) * column 4, line 32 - column 6, line 3; figures 1,2,4-6,9,10 *	11 6,12	
A	US-A-3 993 162 (JUUTI) * column 2, line 20 - line 50; figures *	3-5	
A	GB-A-735 402 (GENERAL ELECTRIC COMPANY LIMITED) * claims; figures *	1,11	
A	EP-A-0 390 165 (SANYO ELECTRIC CO) * page 3, line 55 - page 4, line 42; figures *	1,11	
A	EP-A-0 605 224 (TOKYO SHIBAURA ELECTRIC CO) * column 5, line 31 - column 7, line 56; figures *	1,11	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H04R H04N
A	WO-A-91 19406 (MITSUBISHI ELECTRIC CORP) * abstract; figures *	1,11	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 September 1996	Gastaldi, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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